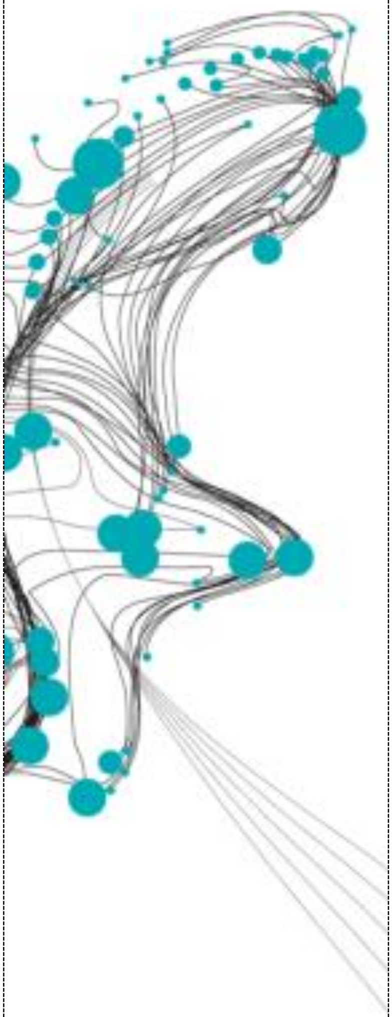
SEDIMENT TRANSPORT UNDER IRREGULAR WAVES



There is an increasing desire to understand and successfully model sand transport in the nearshore zone, where many different hydrodynamic and sediment transport processes take place. Different wave conditions and bed shapes for example can cause sediment to move at the bottom, the place where the largest sediment transport often occurs. So far, research mainly considered regular waves, which had been used for experiments and development of transport formulas. More realistic irregular waves had been left aside.

This thesis focuses on the improvement of the knowledge of these irregular waves, by using the Kranenburg (2013) Boundary Layer Model to explore and explain the differences in sediment transport between irregular and regular waves, according to hydrodynamic and sediment transport related processes. The boundary layer model is a numerical sediment transport model, which can be classified as a one-dimensional Reynolds averaged Navier-Stokes flat-bed boundary layer model with k-ε closure for turbulence and an advection-diffusion formulation for suspended sediment. The model is able to simulate both oscillatory flow tunnels and more realistic wave flumes.

Within this study, the model, initially developed and validated for regular waves, has been validated for sediment transport by irregular waves. This has been done by testing the model with five different irregular wave conditions from full-scale fine and medium sediment wave-flume experiments.

Next, to indicate and explain the sediment transport differences between irregular and regular waves for fine sediment, three methods have been introduced to represent the irregular wave series as a regular wave. In principle, the methods differ in the amount of involvement of the irregular wave signal to define the new velocity skewness and the wave energy, see Figure 1. Subsequently, simulations have been carried out for thirteen irregular wave series and their representative regular waves, and the results for sediment transport rates and concentration profiles have been studied and compared.

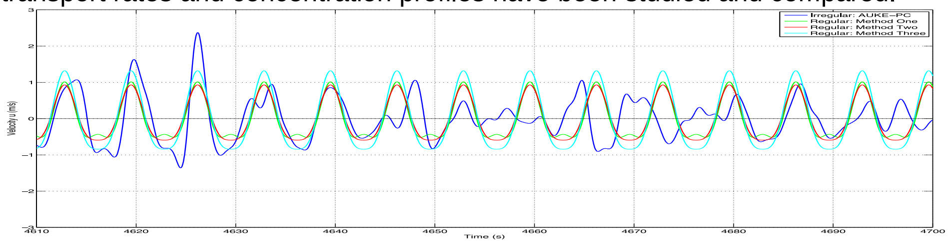


Figure 1: Irregular wave signal and the three representative regular wave signals

The major findings of this study are that: (I) irregular waves encounter a faster transition from onshore to offshore sediment transport in the oscillatory flow tunnel than regular waves, with respect to the third order velocity moment; (II) the net sediment transport for both irregular and regular waves is onshore in the wave-flume; (III) the net sediment transport for irregular waves in the oscillatory flow tunnel is offshore, compared to onshore for regular waves; (IV) this latter difference finds its origin in the wave-related component of the intra-wave horizontal sediment flux and causes “phase lag effects” and appears to create a “pumping effect” (Figure 2); (V) the differences between the net sediment transport direction of irregular waves in oscillatory flow tunnel and wave-flume simulations, is related to compensation of the phase lag effects in the wave-flume case, by a decrease in magnitude of the (offshore) current-related sediment flux component and the influence of orbital motions.

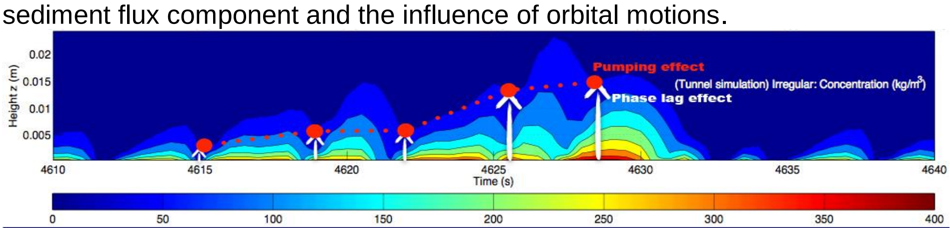


Figure 2: Vertical sediment concentration profile and processes of the irregular wave

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